(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 850 788 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.07.1998 Bulletin 1998/27

(51) Int Cl.6: **B60C 11/00**, B60C 9/22, B60C 3/04

(21) Application number: 97310478.9

(22) Date of filing: 23.12.1997

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 25.12.1996 JP 345985/96

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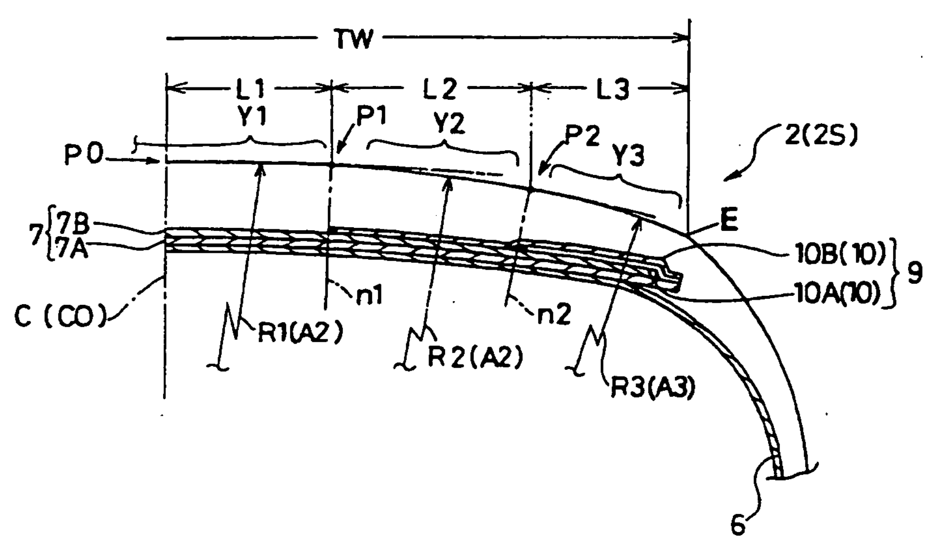
(54) **Pneumatic radial tyre**

(57) A pneumatic radial tyre comprises a breaker-belt (7) disposed radially outside a carcass (6), and a band-belt (9) disposed radially outside the breaker-belt (7) and having organic fibre cords laid substantially parallel with the tyre equator. In the meridian section of the tyre mounted on a standard rim and inflated to 0.5% of standard inner pressure, the tread (2S) has a triple radius profile and the band-belt (9) has a variable ply number (N1,N2,N3) accommodated to the triple radii R1,R2,R3) of the tread. The tread profile is composed of a central part (Y1) of a radius R1, a pair of middle parts (Y2) of a radius R2, and a pair of shoulder parts (Y3) of a radius R3. For example, the ply number N1 in the central part is 0, the ply number N2 in the middle parts is 1, and the ply number N3 in the shoulder parts is 2.

Fig.2



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Description

The present invention relates to a pneumatic radial tyre and more particularly an improved tread portion capable of improving high speed durability, high speed handling, ride comfort, tyre weight and the like.

In general, pneumatic tyres used under high speed conditions such as radial tyres for sports cars, passenger cars and the like are provided in the tread portion with tread reinforcing belts. The belts include a breaker wound on the radially outerside of a carcass and a band or bandage wound outside the breaker. The band usually has a very small cord angle with respect to the tyre equator, for example, 0 plus or minus 5 degrees, and the breaker has a relatively large cord angle. As shown in Fig.7, such a band belt may include one or two full-width bands C2 and optionally one or two edge bands C1. The edge bands C1 are disposed only in the axial edge portions for the purpose of preventing belt edge separation caused by centrifugal force during high speed running. The full-width bands C1 are disposed as the radially outermost belt ply for high speed handling performance.

Such a belt structure greatly increases the rigidity of the tread portion, which as show in Fig.5 lifts the inside tread half (a) from the contact with the ground during cornering, and as a result, as show in Fig.6, the ground contacting area changes its shape from a broader rectangular shape (b) to a undesirable narrow triangular shape (b1). Even in wide-tread tyres whose aspect ratio is less than 60%, it is difficult to maintain the preferable ground contacting shape. Therefore, road grip during cornering decreases, and transitional cornering characteristics are changed greatly. Thus, it is difficult to improve high speed cornering performance, high speed manoeuvrability and the like. Further, it is difficult to improve ride comfort and to decrease the belt weight or the tyre weight.

It is therefore, an object of the present invention to provide a pneumatic radial tyre, in which the band belt is minimised to decrease the tyre weight without decreasing the ability to control the lifting of the belt edges, and at the same time high speed durability, high speed straight running performance and cornering performance, ride comfort and the like are improved.

According to one aspect of the present invention, a pneumatic radial tyre comprises a tread portion with a tread, a pair of sidewall portions, a pair of bead portions, a carcass extending between the bead portions, a breaker-belt disposed radially outside the carcass in the tread portion, and a band-belt disposed radially outside the breaker-belt and having organic fibre cords laid substantially parallel to the tyre equator, wherein, in the meridian section of the tyre, when it is mounted on a standard rim and inflated to 0.5% of standard inner pressure, the tread has a triple radius profile, and the band-belt has a variable ply number accommodated to the triple radii of the tread.

The ply-number of the band-belt is decreased from the belt edges to the tyre equator. Therefore, although the belt edge separation is effectively prevented, the hoop effect is also decreased in the central part, which allows more expansion of the central part. As a result, the ground pressure relatively decreases in the shoulder part, and the heat generation in the shoulder part is decreased to improve the high speed durability.

Further, the expansion of the central part allows the ground contacting area to change from a rectangular shape to a more preferable barrel shape, which increases the ground contacting area during cornering as well as straight running.

Embodiments of the present invention will now be described in detail in conjunction with the accompanying drawings.

Fig.1 is a cross sectional view of a tyre according to the present invention;
Figs.2, 3 and 4 are cross sectional views each showing an example of the belt structure;
Fig.5 is a cross sectional view of a conventional tyre showing deformation of the tread portion during cornering;
Fig.6 is a diagram showing the shape of the ground contacting area thereof; and
Fig.7 shows belt structures (A) to (C) which are used in conventional tyres.

In Fig.1, the pneumatic radial tyre 1 according to the invention comprises a tread portion 2 defining a tread 2S, a pair of axially spaced bead portions 4 each with a bead core 5 therein, a pair of sidewall portions 3 extending between the tread edges and the bead portions 4, a carcass 6 extending between the bead portions 4, and belts 7 and 9 disposed radially outside the carcass 6 in the tread portion 2.

The tyre in this embodiment is a low aspect ratio passenger car radial tyre having a nominal aspect ratio of 50 %.

Fig.1 shows a meridian section of the tyre 1 under 0.5% pressure state in which the tyre is mounted on a standard rim R and inflated to 0.5% of standard inner pressure but loaded with no tyre load.

The standard rim is the standard rim specified in JATMA, the "Measuring Rim" in ETRTO, the "Design Rim" in TRA or the like. The standard pressure is the maximum air pressure in JATMA, the "Inflation Pressure" in ETRTO, the maximum pressure given in the "Tyre Load Limits at Various Cold Inflation Pressures" table in TRA or the like.

Under the 0.5% pressure state, the tread profile will coincide with that of the tyre vulcanising mould. In other words, the tyre 1 is formed by vulcanising a raw tyre in a mould which is provided with an inner face having a profile corresponding to the following tread profile, namely the negative profile of the tread profile.

Under the 0.5% pressure state, the tread 2S has a profile composed of a central part Y1, a pair of middle parts Y2, and a pair of shoulder parts Y3. The central part Y1 is a first curve A1 of radius R1 of which the centre is positioned in the tyre equatorial plane CO. The middle part Y2 is a second curve A2 having a radius R2 less than the radius R1 and is connected to the first curve Al at a first point P1. The shoulder part Y3 is a third curve A3 having a radius R3 less than the radius R2 and is connected to the second curve A2 at the second point P2. Thus the tread portion 2 has a triple radius tread 2S. (R1 > R2 > R3)

Preferably, the radius R1 is about 4.5 to 6.0 times the tread width TW between the tread edges E. The radius R2 is about 0.6 to 0.3 times the radius R1. The axial distance L1 between the first point P1 and the tread equator is about 0.34 to 0.24 times the tread width TW. The axial distance L2 between the first point P1 and the second point P2 is less than the distance L1 and about 0.43 to 0.33 times the tread width TW. The axial distance L3 between the second point P2 and the tread edge E is more than the distance L1 and less than the distance L2 and about 0.38 to 0.28 times the tread width TW.

The carcass 6 comprises at least one ply of cords arranged at an angle of from 75 to 90 degrees with respect to the tyre equator C, extending between the bead portions 4 through the tread portion 2 and sidewall portions 3, and turned up around the bead cores 5 from the inside to the outside of the tyre so as to form a pair of turnup portions 6b and a main portion 6a therebetween. For the carcass cords, organic fibre cords, e.g. polyester, rayon, nylon or the like are used.

In this embodiment, the carcass 6 is composed of a single ply. Between the main portion 6a and each turnup portion 6b, a bead apex 8 made of hard rubber tapering and extending radially outwardly from the bead core 5 is disposed. The radially outer end of the carcass ply turnup portion 6b is located radially outwards of the radially outer end of the bead apex and the so called high-turnup structure.

The breaker-belt 7 comprises at least two plies of parallel cords laid at an angle of from 15 to 30 degrees with respect to the tyre equator C.

For the breaker-belt cords, non extensible or tension resistant high modulus cords, e.g. aromatic polyamide fibre cords, steel cords and the like can be used. Especially, steel cords are preferably used.

In the case of passenger tyres, it is preferable that the breaker-belt is composed of two crossed plies in view of the rigidity and weight. Thus in this example, the breaker-belt 7 is composed of a radially inner ply 7A and a radially outer ply 7B, the cords in each ply are parallel with each other but crosswise to the next ply.

In order to reduce stress concentration at the edges, the inner breaker-belt ply 7A is formed to be wider than the outer breaker-belt ply 7B. The axial width WB of the inner ply 7A is set in the range of from 0.85 to 1.1 times the tread width TW to reinforce the substantially entire width of the tread portion 2.

The above-mentioned band-belt 9 is made of cords laid at an angle of substantially zero degree with respect to the tyre equator C. The band-belt 9 comprises a plurality of plies 10, the ply-number of which is changed according to the above-mentioned triple radii R1-R3. The ply-number N1 in the tread central part Y1, the ply-number N2 in the tread middle parts Y2 and the ply-number N3 in the tread shoulder parts Y3 are different from each other. Preferably, N1 > N2 > N3.

In the case of a passenger car tyre, it is preferable that N1=0, N2=1 and N3=2, but it is also possible that N1=1, N2=2 and N3=3.

It is possible to form the band ply by winding a strip of tyre fabric and splicing the circumferential ends thereof.

However, it is preferable that the band is formed by spirally winding one or more cords around the radially outer surface of the breaker belt at an angle of almost zero degree with respect to the tyre equator C.

For the band cords, organic fibre cords, e.g. nylon, rayon, polyester and the like having a tensile elastic modulus of less than 1000 kg/sq.mm are used. Especially, nylon fibre cords are suitably used for their good durability against bending deformation and processability.

In the case of a spiral band, the band ply is formed by spirally winding a ribbon of rubber in which two or three cords are embedded along the length thereof.

Fig.2 shows an example in which the ply-numbers N1=0, N2=1 and N3=2. accordingly, the band-belt 9 is composed of a pair of axially spaced parts, each composed of a radially inner narrow ply 10A and a radially outer wide ply 10B. Each of the inner plies 10A is disposed on the radially outside of the breaker-belt 9 to cover each edge thereof. The outer ply 10B is disposed on the radially outside of the inner ply 10A.

The axially outer edges of the inner and outer plies 10A and 10B are substantially aligned with the breaker edges or the edges of the widest inner breaker-belt ply 7A so that the axial distance measured axially outwardly from the axially outer end of the inner breaker-belt ply 7A is preferably in the range of from 0 to 3 mm.

The axially inner edge of the inner ply 10A reaches near to a straight line n2 normal to the tread 2S which is drawn radially inwardly from the second point P2. The axially inner edge of the outer ply 10B reaches near to a straight line nl normal to the tread 25 which is drawn radially inwardly from the first point P1.

It is preferable that the axially inner edges of the band plies 10A and 10B are positioned on the normal lines n1 and n2 so that the ply-number is zero throughout the central part Y1, one throughout the part Y2 and two throughout

the part Y3.

In practice, however, it is possible to somewhat shift axially inwardly or outwardly from the normal lines. The dislocation K should be limited to less than 0.2 times, preferably 0.1 times, more preferably 0.05 times a distance which is the axial distance L1, L2 or L3 of the part Y1, Y2 or Y3 in which the ply edge is located.

On the other hand, it is not preferable that the axially inner edges are positioned just under circumferential grooves because stress is liable to concentrate on the ply edges and thus cracks are liable to occur in the groove bottom. Therefore, in order to prevent cracks, as shown in Fig.4, the end of the inner ply 10A is shifted axially outwardly, and the end of the outer ply 10B is shifted axially inwardly.

In this case, the dislocation KO depends on the groove width but it should be limited to less than 0.4 times a distance which is the axial distance L1, L2 or L3 of the part Y1, Y2 or Y3 in which the ply edge is located.

When tile end of the Inner ply is shifted from the line n2 into the part Y3, the dislocation KO is less than 0.4 times L3. However, if the end is shifted into the part Y2, the dislocation KO is less than 0.4 times L2.

When the end of the outer ply is shifted from the line nl into the part Y1, the dislocation KO is less than 0.4 times L1. However, if the end is shifted into the part Y2, the dislocation KO is less than 0.4 times L2.

Comparison Tests

Test tyres having the structure shown in Figs.1 and 2 were made and tested for high speed durability, high speed handling, ride comfort and tyre weiqht.

Tyre size: 225/50ZR16

Rim size: 7 1/2X16

The specifications of the tyres and test results are shown in Table 1.

1) High Speed Durability Test

Using a tyre test drum, the durability was measured by increasing the running speed at a step of 10 km/h every 10 minutes from 200 to 240 km/h and then every 20 minutes from 240 km/h, and the speed at which the tyre failed and the time period at that speed before failure was measured.

Tyre load: 375 kgf

Inner pressure: 3.0 kg/sq.cm

2) High Speed Handling Test

A 3000cc FR passenger car provided on all the wheels with test tyres was run on a test circuit course and the lap time was measured. Then high speed running, the controllability, road grip and handling response during critical cornering, and the straight running stability were evaluated into ten ranks by the test driver's feeling. The higher the rank, the better the performance.

3) Ride Comfort Test

The ride comfort of each tyre was evaluated into one of ten ranks by the driver's feeling. The higher the rank, the better the ride comfort.

From the test results, it was confirmed that the tyre according to the present invention was improved in high speed handling performances and durability, covering a wide range of camber angle, due to the ground contacting area shape and ground pressure distribution which were improved by specifically combining the triple radius tread profile and band-belt structure.

Table 1

Tire	Ex.1	Ref.1	Ref.2
Tread radius	triple	triple	double
R1 (mm)	1100	1100	800
R2 (mm)	400	400	800
R3 (mm)	200	200	300
L1 (mm)	30	30	70
L2 (mm)	40	40	70
L3 (mm)	35	35	35

Table 1 (continued)

Tire	Ex.1	Ref.1	Ref.2
Band Ply-number	Fig.2	Fig.7(A)	Fig.7(A)
N1	0	1	1
N2	1	1	1
N3	2	2	2
Ply width (mm)			
Full-width ply	-	105	105
Outer ply	75	-	-
Inner ply	35	35	35
High speed durability (km/h x minutes)			
0 deg. camber	310X15	300X15	290X10
2 deg. camber	300X10	280X10	270X5
4 deg. camber	300X5	260X10	250X10
High speed performance Straight running stability	7	6	6
Cornering Controlability	8	6	5
Road grip	8	6	5
Handle response	8	6	5
Lap time	1'59"	2'04"	2'07"
Ride comfort	6	5	5
Tire weight (kg)	10.2	10.3	10.3

Claims

1. A pneumatic radial tyre comprising a tread portion (2) with a tread (2S), a pair of sidewall portions (3), a pair of bead portions (4), a carcass (6) extending between the bead portions (4), a breaker-belt (7) disposed radially outside the carcass (6) in the tread portion (2), a band-belt (9) disposed radially outside the breaker-belt (7) and having organic fibre cords laid substantially parallel with the tyre equator, characterised in that in the meridian section of the tyre when it is mounted on a standard rim and inflated to 0.5% of standard inner pressure, the tread (2S) has a triple radius profile and the band-belt (9) having a variable ply number (N1,N2,N3) accommodated to the triple radii of the tread.

2. A pneumatic radial tyre according to claim 1, characterised in that the tread profile is composed of a central part (Y1) defined by a first curve (Al) of radius R1 having the centre in the tyre equatorial plane (CO), a pair of middle parts (Y2) each defined by a second curve (A2) of a radius R2 smaller than the radius R1 and merged into the first curve (A1) at a first point (P1), and a pair of shoulder parts (Y3) each defined by a third curve (A3) of a radius R3 smaller than the radius R2 and merged into the second curve (A2) at a second point, and the ply number N2 in the middle parts is less than the ply number N3 in the shoulder parts but more than the ply number N1 in the central part.

3. A pneumatic radial tyre according to claim 2, characterised in that the ply number N1 is 0, the ply-number N2 is 1, and the ply-number N3 is 2.

4. A pneumatic radial tyre according to claim 2, characterised in that a half axial width L1 of the central part Y1 is 0.34 to 0.24 times the tread width TW, the axial width L2 of each middle part Y2 is less than the width L1 and 0.43 to 0.33 times the tread width TW, the axial width L3 of each shoulder part Y3 is more than the width L1 but less than the width L2 and 0.38 to 0.28 times the tread width TW, the radius R1 of the central part is 4.5 to 6.0 times the tread width TW, the radius R2 of the middle parts is 0.6 to 0.3 times the radius R1.

Fig.1

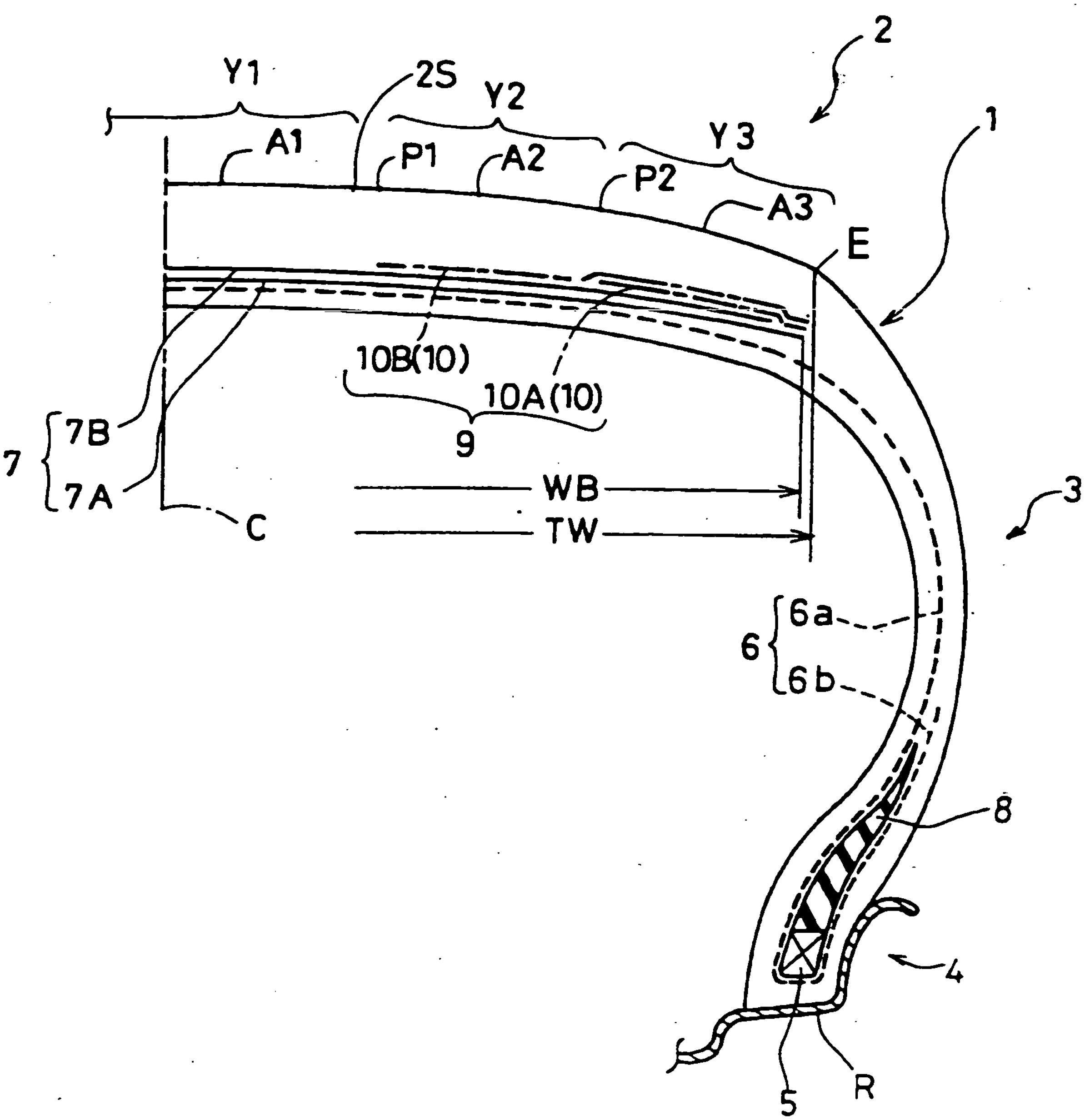

2
Y1
2S
Y2
1
Y3
A1
P1
A2
P2
A3
E
10B(10)
10A(10)
9
7B
7
7A
C
WB
TW
3
6a
6
6b
8
4
5
R

Fig.2

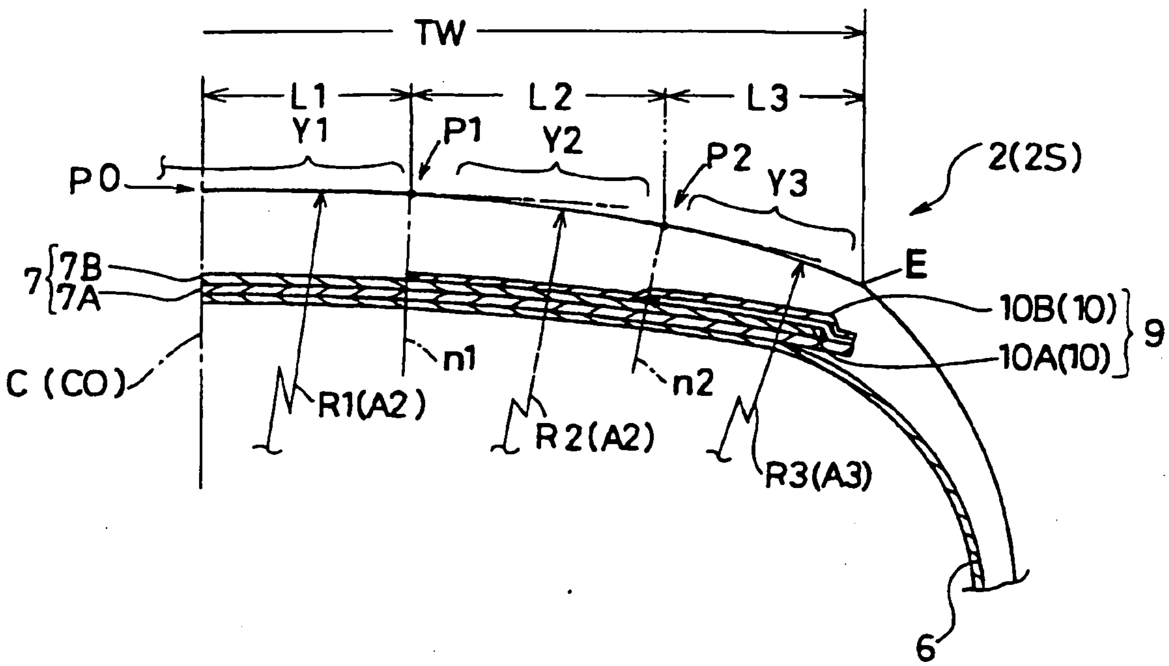

TW
L1
L2
L3
Y1
P1
Y2
P2
Y3
2(2S)
P0
7
7B
7A
E
10B(10)
9
10A(10)
C (CO)
n1
n2
R1(A2)
R2(A2)
R3(A3)
6

Fig.3

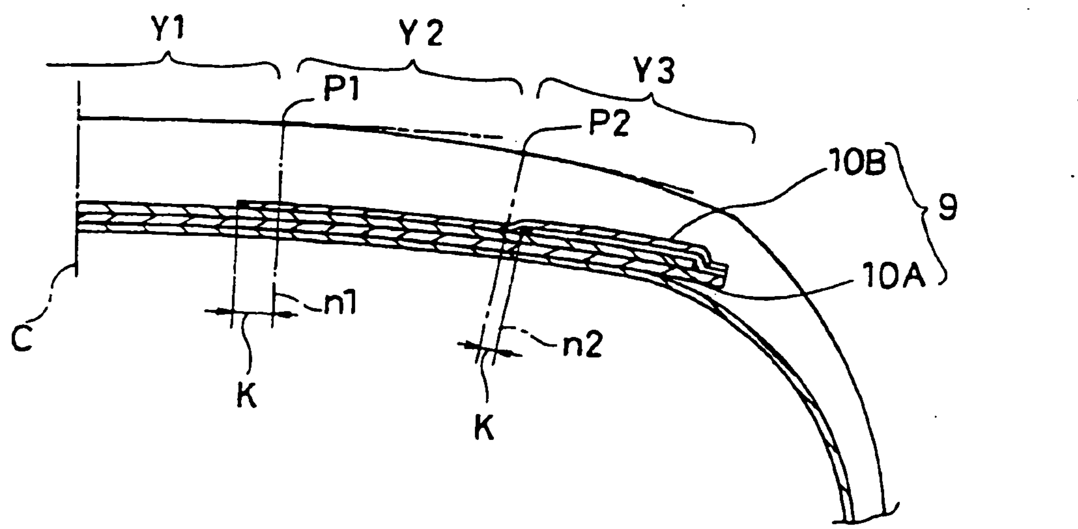

Y1
Y2
Y3
P1
P2
10B
9
10A
C
n1
n2
K
K

Fig.4

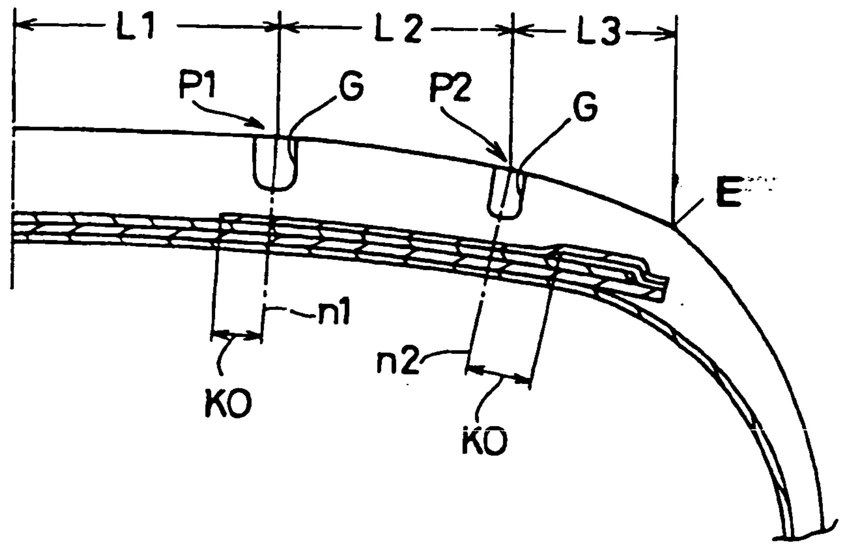


Fig.5

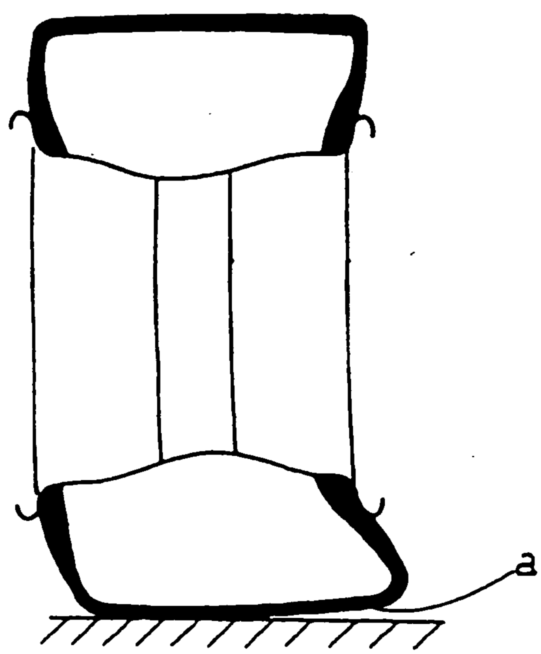


Fig.6

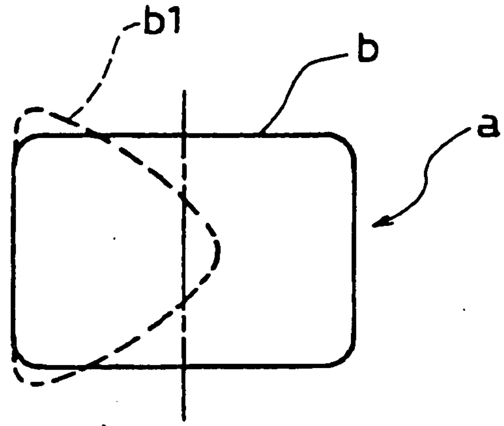
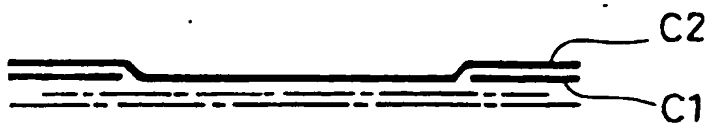
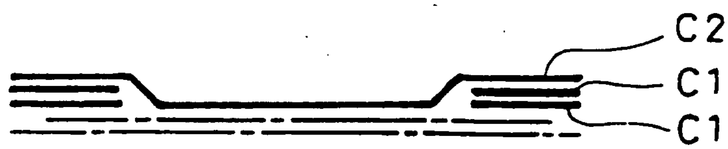


Fig.7

(A)



(B)



(C)

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EUROPEAN SEARCH REPORT

Application Number
EP 97 31 0478

Category	DOCUMENTS CONSIDERED TO BE RELEVANT Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	EP 0 402 303 A (GOODYEAR TIRE & RUBBER) * page 3, line 15 - line 24; figures 4,5 * * page 1, line 1 - line 7 * * page 3, line 35 - line 52 * ---	1,2,4	B60C11/00 B60C9/22 B60C3/04
Y	EP 0 424 155 A (SUMITOMO RUBBER IND) * page 1, line 1 - line 4; claims; figures 1,4 * * page 4, line 55 - page 5, line 18 * ---	1,2,4	
A	EP 0 313 362 A (BRIDGESTONE CORP) * column 2, line 19 - column 4, line 12; claims; figures * ---	1-3	
A	EP 0 739 759 A (BRIDGESTONE CORP) * page 2, line 1 - line 22; claims; figures * ---	1,4	
A	DE 40 02 824 A (BRIDGESTONE CORP) * column 5, line 64 - column 7, line 12; figures * -----	1-4	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B60C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	6 April 1998	Baradat, J-L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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